LHCC Poster Session - CERN, 5 March 2014

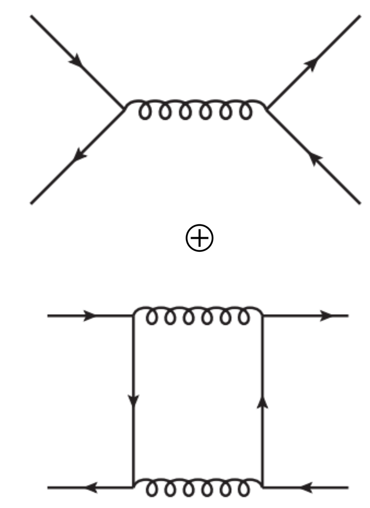
The Top Charge Asymmetry in $\sqrt{s}$=7 TeV p-p collisions at ATLAS

Introduction

The top quark is the heaviest elementary particle observed so far. As its mass is close to the electroweak scale, measurements of top quark properties, such as the charge asymmetry in the production of top quark pairs, might provide hints of new physics beyond the Standard Model. It is therefore interesting to measure the top charge asymmetry as precisely as possible.

SM QCD

1.



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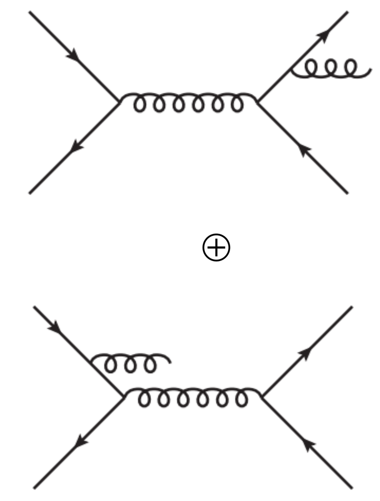
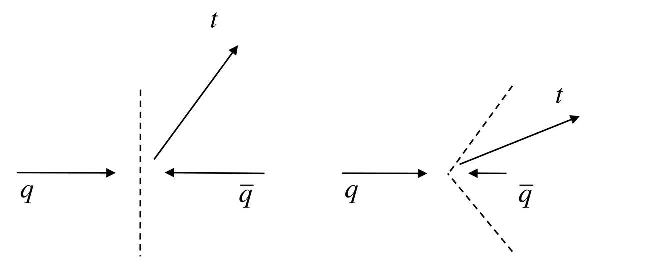


The SM asymmetry originates from
1. Interference between leading order s-channel diagram and one loop correction (box diagram)
2. Interference between final state and initial state gluon emission diagrams

Asymmetry @ LHC

The asymmetry is only present in $q\bar{q} \to t\bar{t}$ process, where the produced (anti)top quark is preferentially produced along the direction of the incoming (anti)quark.
- small in Standard Model: NLO contribution
- possibly enhanced in BSM



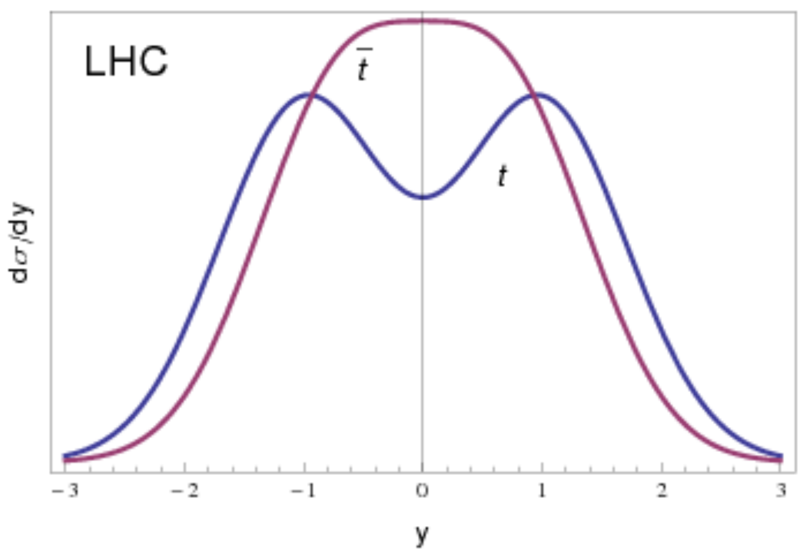
CM reference frame — Lab reference frame

In p-p collisions, the direction of the incoming quark is not known. However, quarks are more likely to be valence quarks, while only sea anti-quarks are available. This causes a momentum imbalance, reflected in the rapidity distribution being broader for top quarks than for antitops.

Observable used to measure the asymmetry:

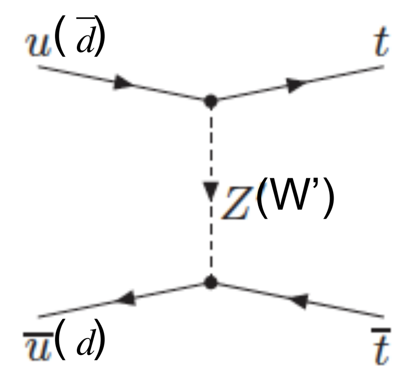
$$A_C = \frac{N(\Delta|Y|>0) - N(\Delta|Y|<0)}{N(\Delta|Y|>0) + N(\Delta|Y|<0)}$$

with $\Delta|Y| = |Y_{top}| - |Y_{antitop}|$



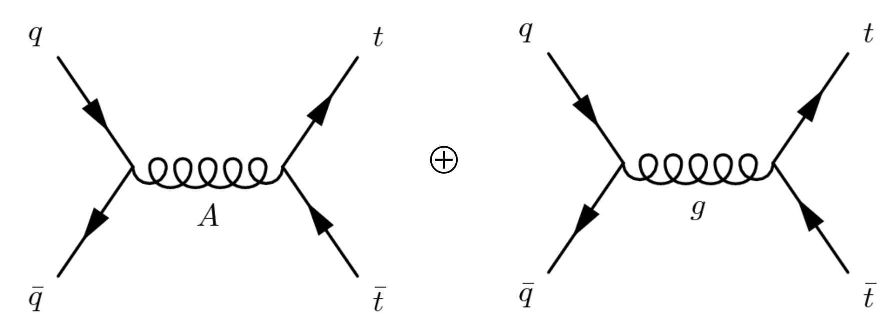
Rapidity distributions of top and antitop quarks at the LHC. G.Rodrigo, arxiv:1207.3301

BSM Z'/W'



The coupling with exotic vector bosons would introduce an asymmetry in the leading order t-channel diagrams.

BSM axigluon



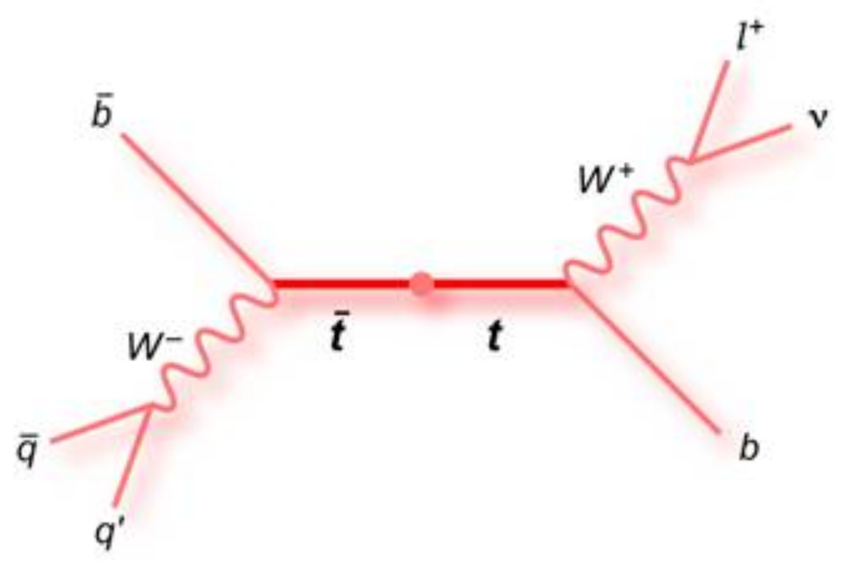
In axigluon models the asymmetry arises from the interference between the leading order s-channel axigluon and gluon diagrams.

Analysis Strategy

The measurement is performed by selecting and reconstructing top pair events in lepton+jets final states. The $\Delta|y|$ distribution is then unfolded to estimate the parton-level asymmetry A_C.

Event Selection

- single lepton trigger
- one isolated lepton (electron, E_T>25 GeV, or muon, p_T>20 GeV), matching the corresponding high level trigger object.
- at least 4 jets with p_T>25 GeV
- at least 1 *b*-tagged jet with p_T>25 GeV



lepton+jets channel:
one W decays to lepton+neutrino and the other one to a pair of quarks.

Kinematic Reconstruction

The top-antitop pair system is fully reconstructed using a kinematic likelihood method.

Likelihood input:
- 4-momenta of four jets
- 4-momentum of the lepton
- missing transverse momentum

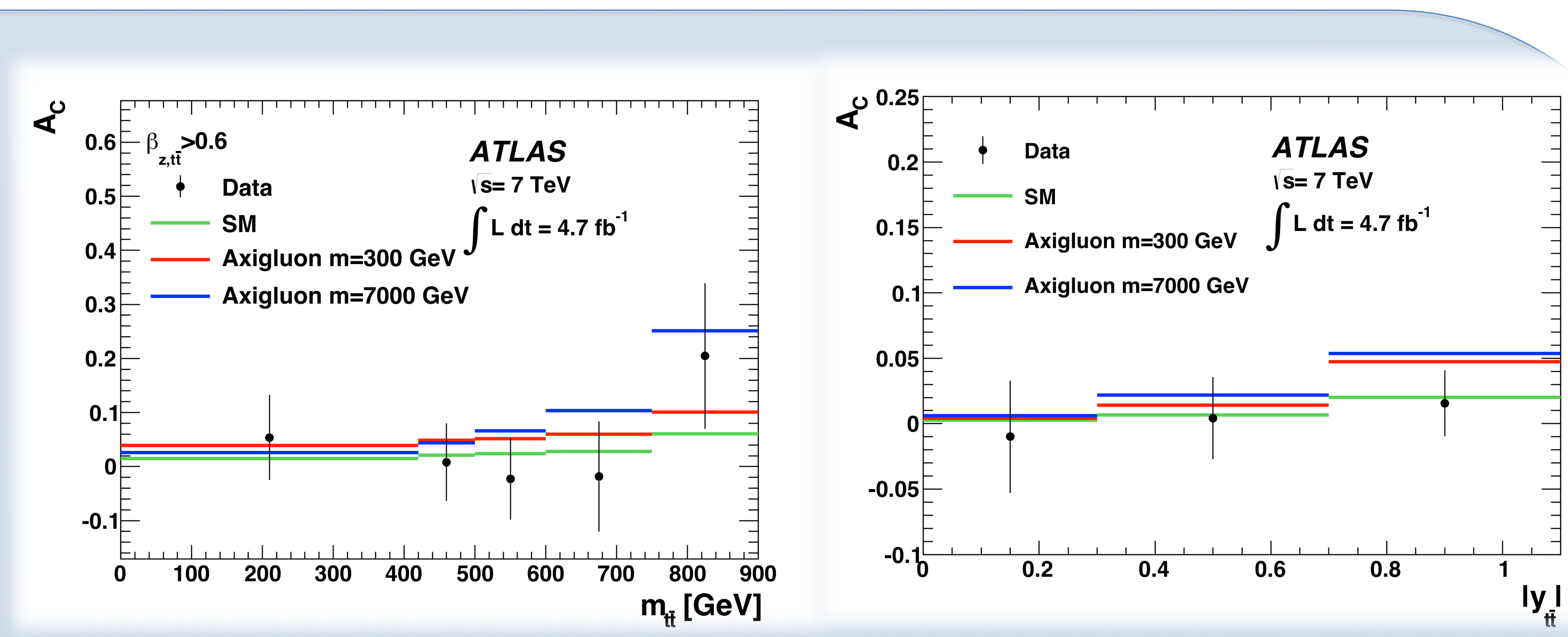
Constraints:
- top mass and width: m_t=172.5 GeV, Γ_t=1.5 GeV
- W mass and width: m_W=80.4 GeV, Γ_W=2.1 GeV

Results

Asymmetry measurements:
- inclusive A_C
- A_C at high top pair mass (m_{tt}>600 GeV)
- A_C for z-boosted top pairs ($\beta_{z,tt}$>0.6)
- differential A_C vs m_{tt} (w/ and w/o $\beta_{z,tt}$>0.6)
- differential A_C vs $p_{T,tt}$
- differential A_C vs $|y_{tt}|$

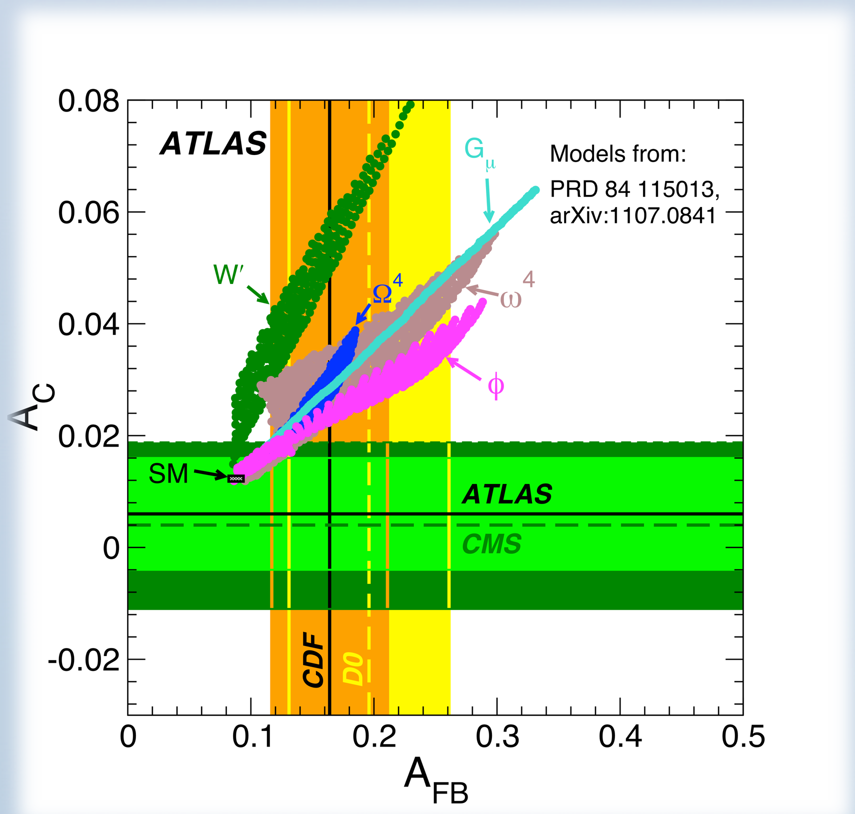
Unfolded	Theory[1]
A_C= 0.006 ± 0.010	0.0123 (5)
$A_C(m_{tt}$>600 GeV)= 0.018 ± 0.022	0.0175 (5)
$A_C(\beta_{z,tt}$>0.6)= 0.011 ± 0.018	0.020 (7)

Uncertainties are (stat.+syst.).
- Statistical error is the largest component.
- Main systematics: jet energy scale and resolution.

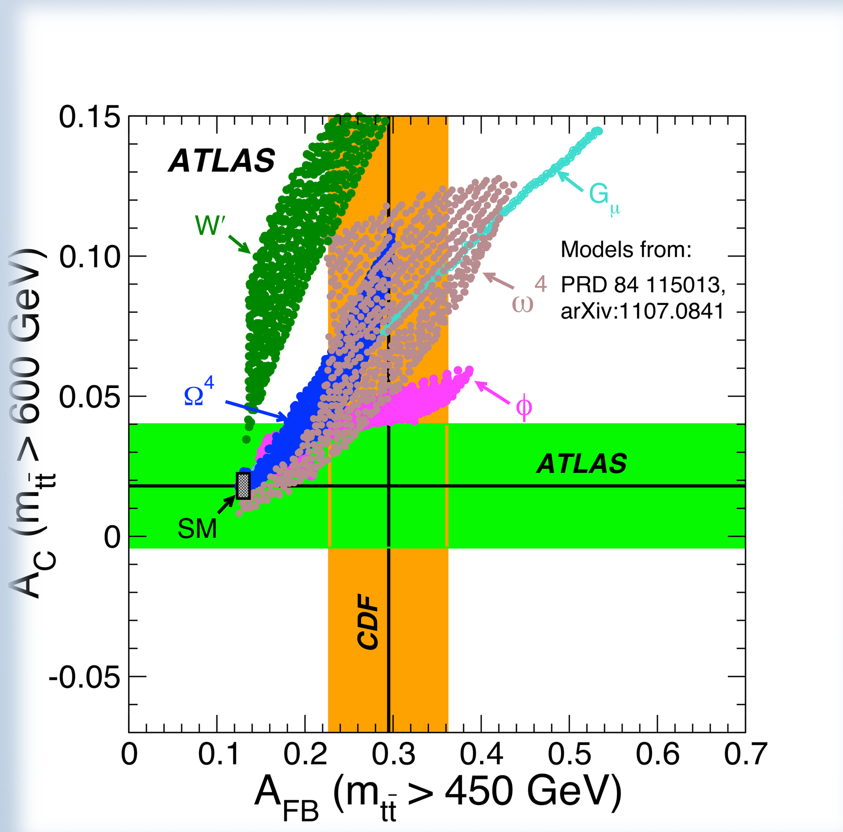


Unfolded A_C spectra as a function of m_{tt} for top pairs boosted along the z-axis (left) and as a function of $|y_{tt}|$ (right). The unfolded A_C spectra (black markers) are compared with the SM predictions[1] (green lines) and the predictions for color-octet axigluons[2] with mass of 300 GeV (red lines) and 7000 GeV (blue lines).

1. W. Bernreuther and Z.-G. Si, Phys. Rev. D 86 (2012) 034026
2. J. A. Aguilar-Saavedra and M. Perez-Victoria, JHEP 1105 (2011) 034



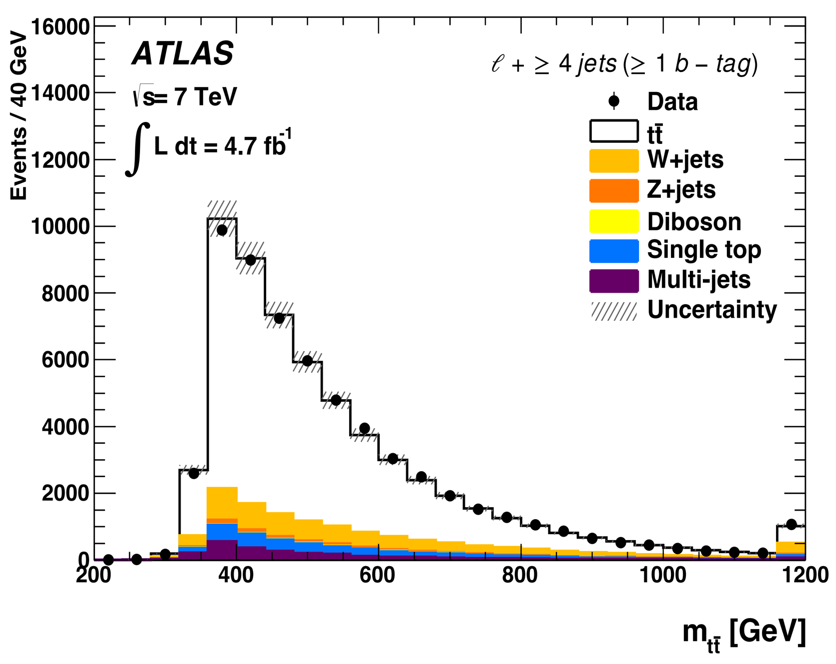
Inclusive A_{FB} and A_C measurements.



CDF A_{FB} measurement for m_{tt}>450 GeV and ATLAS A_C measurement for m_{tt}>600 GeV.

Tevatron&LHC vs BSM

- Tevatron forward-backward asymmetry A_{FB} and LHC charge asymmetry A_C compared to the SM (black box) and BSM expectations.
- The horizontal bands and lines correspond to ATLAS (light green) and CMS (dark green) measurements, the vertical ones to CDF (orange) and D0 (yellow).
- While Tevatron results show some tension with the SM predictions, the LHC measurements are compatible with the SM predictions.
- The W' scenario is disfavored by the combination of A_C and A_{FB} measurements.



Distribution of the reconstructed invariant mass of the top pair. Data (dots) and SM expectations (solid lines) are shown. The uncertainty on the total prediction includes both the statistical and the systematic components.

Unfolding

- Distortions due to acceptance and resolution effects are taken into account with an unfolding procedure.
- The Fully Bayesian Unfolding algorithm (*arxiv:1201.4612*) estimates the posterior probability for the parton-level distribution T given a distribution D measured in data

$$p(\mathbf{T}|\mathbf{D}) \propto \mathcal{L}(\mathbf{D}|\mathbf{T}) \cdot \pi(\mathbf{T})$$

- The posterior probability $p(\mathbf{A_C}|\mathbf{D})$ is then computed.

- The likelihood of observing D given T is

$$\mathcal{L}(\mathbf{D}|\mathbf{T}) = \prod_{i=1}^{n} Poisson(d_i, r_i(\mathbf{T}, \mathcal{M}))$$

$$r_i(\mathbf{T}, \mathcal{M}) = \sum_{j=0}^{n} \epsilon(t_j) p(r_i|t_j)$$

migration probability (resolution)

acceptance

where **R** is the estimated spectrum after reconstruction.

- The prior $\pi(\mathbf{T})$ is used to implement a Tikhonov regularization in the algorithm.

arXiv:1311.6724 accepted by JHEP

Francesco Rubbo, for the ATLAS Collaboration

ATLAS EXPERIMENT